HETA 98-0334-2739
Pike Industries, Inc.
South Burlington, Vermont

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PREFACE

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ACKNOWLEDGMENTS AND AVAILABILITY OF REPORT

This report was prepared by David C. Sylvain, of the Hazard Evaluations and Technical Assistance Branch, Division of Surveillance, Hazard Evaluations and Field Studies (DSHEFS). Analytical support was provided by DataChem Laboratories, Inc., and the Division of Physical Sciences and Engineering (DPSE). Desktop publishing was performed by Pat Lovell. Review and preparation for printing was performed by Penny Arthur.

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Health Hazard Evaluation Report 98-0334-2739
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South Burlington, Vermont
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SUMMARY

On October 21, 1998, the National Institute for Occupational Safety and Health (NIOSH) conducted an industrial hygiene evaluation of worker exposure to an asphalt anti-strip additive and to asphalt fume during paving operations on route I-91 in Vermont. The evaluation was conducted in response to management concern about paving crew workers' reports of headaches, upset stomach, fatigue, rashes, itchy eyes, and sore throats when using hot mix asphalt (HMA) containing a specific additive.

Air samples were collected to assess exposure to asphalt fume and components of the aliphatic polyamine anti-strip additive. Asphalt fume interfered with the detection, identification, and quantification of amine compounds. Only a few nitrogen-containing compounds were identified; however, the evaluation of total nitrogen, a marker for amines, indicated the presence of low concentrations of additional unidentified nitrogen-containing compounds (presumably amines). Since the total nitrogen values did not measure exposure to specific compounds, it is difficult to relate these results to possible health effects of exposure to specific aliphatic amines, or to a class of amines.

Workers' exposures to asphalt fume, measured as total particulate, were less than 5 milligrams per cubic meter of air (mg/m^3) concentration established by the American Conference of Governmental Industrial Hygienists (ACGIH) as an 8-hour time-weighted average (TWA) Threshold Limit Value (TLV®). Since personal breathing zone (PBZ) and area samples were collected over periods ranging from 441 to 509 minutes, the results of these samples cannot be evaluated in terms of the 15-minute ceiling of 5 mg/m^3 (measured as total particulate) established by NIOSH as a Recommended Exposure Limit (REL).

Workers were exposed to low levels of nitrogen-containing compounds while paving with HMA treated with a polyamine anti-strip additive. These compounds included several identified amines, as well as unidentified nitrogen compounds, which are presumed to have been amines. Without knowing the identities and concentrations of specific amines, the relationship between these compounds and potential health effects remains unclear.

Keywords: SIC 1611 (Highway and Street Construction), asphalt anti-strip additives, asphalt fume, aliphatic polyamines, bitumen, paving.

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INTRODUCTION

On September 3, 1998, the National Institute for Occupational Safety and Health (NIOSH) received a request for a health hazard evaluation (HHE) from a representative of Pike Industries, Inc. for an evaluation of worker exposure to an asphalt anti-strip additive during hot mix asphalt (HMA) paving. The request indicated that paving crew workers reported experiencing headaches, upset stomach, fatigue, rashes, itchy eyes, and sore throats when using HMA containing Wetfix 312 anti-strip additive, a proprietary aliphatic polyamine mixture.

On October 21, 1998, NIOSH conducted an industrial hygiene evaluation of worker exposure to the anti-strip additive and asphalt fume during paving operations on route I-91 in Vermont. The evaluation included the collection of area air samples to characterize the asphalt fume emission, and personal breathing zone (PBZ) air samples to evaluate worker exposures.

BACKGROUND

Process Overview

There are three basic steps in constructing an asphalt pavement: manufacture of HMA, placement of the mix onto the ground, and compaction. The asphalt mix contains two primary ingredients, a binder which is typically an asphalt cement, and an aggregate which is usually a mixture of coarse and fine stones, gravel, sand, and other mineral fillers. The mix design establishes the proportions of the aggregate materials and sizes to the amount of asphalt cement, to obtain the appropriate pavement properties (flexibility, drainage, durability, etc.).

The purpose of an HMA plant is to blend the aggregate and asphalt cement to produce a homogenous paving mixture at a hot temperature so that it can be easily applied and compacted. Asphalt cement is typically received from a refinery by tractor trailer tankers and is transferred into heated storage tanks. Aggregate of different materials and sizes is blended through a series of belt conveyors and a dryer (a heated drum mixer). Once the aggregate is sufficiently blended and dried, asphalt cement is applied so that a continuous thin film of cement covers the aggregate evenly. The finished HMA is then placed in a storage silo until it can be dispensed into trucks that haul the material to the paving site. At the paving site the following equipment is typically used:

- Tack truck: A vehicle which precedes the paver and applies a low viscosity asphalt ("tack" coat) to the roadway to improve adhesion prior to the HMA placement.
- Paver: A motorized vehicle which receives the HMA from the delivery trucks and distributes it on the road in the desired width and depth. The HMA may be transferred from the delivery truck to the paver by: (1) directly pouring HMA into a hopper located in the front of the paver; (2) dumping HMA in a line onto the road where it is picked up by a windrow conveyor and loaded into the paver hopper; or (3) conveying the mix with a material transfer vehicle.
- Screed: Located at the rear of the paver, the screed distributes the HMA onto the road to a preselected width and depth and grades the HMA mix to the appropriate slope as the paving vehicle moves forward.
- Rollers: Typically two or three roller vehicles follow the paver to compact the asphalt.

Paving crews normally consist of eight to ten workers. Job activities include a foreman who supervises the crew; a paver operator who drives the paver; one or two screed operators who control and monitor the depth and width of the HMA placement; one or two rakers who shovel excess HMA, fill in voids and prepare joints;

laborers who perform miscellaneous tasks; roller operators who drive the rollers; and a tackman who applies the tackcoat. The paver operators and roller operators do not usually perform different jobs, while the screed operators, rakers, and laborers may perform a variety of tasks throughout the workday.

Site Description

The paving site was in the southbound lanes of route I-91, several miles north of White River Junction, Vermont. Equipment used at the site consisted of a Blaw Knox PF3200 paver, RoadTec SB-2500 Shuttle Buggy transfer vehicle, and three rollers. Seven people worked on or near the paver and Shuttle Buggy. These individuals were the paver operator, two back-end operators (at paver screed), Shuttle Buggy operator, truck dumper (at Shuttle Buggy hopper), and two flag people.

The HMA used on I-91 was Superpave Type III HMA, which was supplied by the Pike asphalt plant in West Lebanon, New Hampshire. Aggregates (fine and coarse) were also produced and supplied by the West Lebanon plant. The HMA was manufactured and applied according to the specifications of the Vermont Agency of Transportation. The asphalt cement binder was Petro-Canada 58-34. Wetfix 312 anti-strip additive was added to the binder at the rate of 0.5% to promote adhesion and reduce stripping. HMA was delivered to the site by tri-axle dump trucks and Flow-Boy semi-trailers. The “truck dumper” guided the trucks to the hopper on the Shuttle Buggy, where HMA was unloaded. The HMA was transferred from the hopper into the enclosed body of the Shuttle Buggy via an enclosed conveyer on the Shuttle Buggy. The Shuttle Buggy operator, who sat on top of the Shuttle Buggy, controlled the ground-speed of the Shuttle Buggy, and the elevators which carried HMA into the Shuttle Buggy, and subsequently to the hopper on the paver. The paver applied HMA at an average rate of 240 tons per hour, which required a forward speed of approximately 25 to 35 feet per minute. The uncompacted mat thickness was 2.125 to 2.25 inches, and the laydown width ranged from 10 to 16 feet. The laydown temperature was approximately 300°F.

METHODS

The industrial hygiene evaluation consisted of: (1) environmental sampling during paving operations, and (2) observation of work practices. Air samples were collected using calibrated battery-operated sampling pumps with the appropriate sorbent tube or filter media connected via Tygon® tubing. The area and PBZ sample concentrations were calculated based on the actual monitoring time (time-weighted average [TWA-actual] concentrations). Calibration of the air sampling pumps with the appropriate sampling media was performed before and after the monitoring period. Field blanks were collected and submitted to the laboratory for each analytical method.

Area Air Sampling

Area samples were collected for nitrogen-containing compounds (amines), and asphalt fume (total particulate, benzene soluble fraction, and polycyclic aromatic compounds). To evaluate worst-case conditions and to characterize the asphalt fume, an area air sample was collected above the screed auger of the paver. Additional area samples (“seat samples”) were collected at the operator’s seat on the paver to obtain an estimate of the operator’s exposure.

Personal Air Sampling

The screed operator and paving foreman were selected for PBZ sampling because of their close proximity to asphalt fume. The paving foreman remained at, or near, the screed throughout most of the day.

Aliphatic Amines

Two bulk samples of Wetfix 312 were submitted for qualitative analysis: one sample was submitted by Pike Industries prior to the NIOSH site visit; the other sample was obtained at the bulk plant on the sampling date. Analysis consisted of dissolving a portion of each sample in ethanol and analyzing by gas chromatography-mass spectrometry (GC-MS).

Bulk samples of untreated asphalt and asphalt containing 0.5% Wetfix 312 were collected at the bulk plant on the sampling date. Analysis was performed by heating the bulk samples to approximately 160°C and collecting headspace samples on quartz filters/XAD-2 media, extracting the samples with two milliliters (ml) of ethanol, and analyzing by GC-MS.

Air samples were collected using Occupational Safety and Health Administration (OSHA) Versatile Samplers (OVS-2 tubes) which have a quartz fiber filter, and front and back sections containing XAD-2 sorbent. Each OVS-2 sample was collected at a nominal flow rate of 1.0 liter per minute (lpm), and was kept under refrigeration prior to analysis.

The procedure for analyzing 1-nitropyrene in diesel particulates was modified for the analysis of the air samples collected during HMA paving. This analysis utilized a GC/nitrogen chemiluminescence detector (NCLD) system where the GC separated the sample components, and the NCLD detected and quantitated peaks resulting from nitrogen-containing compounds.

Air samples were prepared by extracting the samples with ethanol: the quartz fiber filter and the front media bed were extracted in a single vial; the rear media bed was extracted in a separate vial, and treated as a second sample. Each vial (containing media and ethanol) was capped with a Teflon™-lined screw cap, and placed on a Labquake rotary shaker for overnight rotary extraction. Following extraction, an aliquot of the extract was place in a micro-volume insert in a GC autosampler vial. The vial was sealed with a crimp-top septum seal, and analyzed using a GC/NCLD. The total nitrogen mass in each air sample was calculated by summing the area of all nonsolvent peaks detected by the NCLD. This value was: (1) reported as the total nitrogen mass for each sample (ng/sample), and (2) converted from a nitrogen value to a compound mass value based on the nitrogen/mass ratio of selected compounds. Since standards of Wetfix 312 were not available, 1-nitropyrene was used as the calibration standard. No recovery or storage studies were performed on Wetfix 312 or the identified amine compounds. Analytical results were reported to the nearest 50 nanograms (ng) per sample, with a relative accuracy of approximately ±50%.

Asphalt Fume

Asphalt fume exposures have typically been measured as total particulates (TP) and the benzene-soluble particulate fraction (BSF) of the particulates. However, since neither of these measure exposure to a distinct chemical component, nor a distinct class of chemicals, it is difficult to relate them to possible health effects. For example, many organic compounds are soluble in benzene, and road dust will contribute to total particulate levels. In an effort to address this situation, polycyclic aromatic compounds (PACs) which may be present in asphalt fume, were measured using a relatively new analytical method. Some of the PACs are believed to have irritative effects while other PACs are suspected to be carcinogenic.

Total Particulate/Benzene Soluble Fraction (TP/BSF)

Each sample was collected on a tared 37-millimeter (mm) diameter, 2-micrometer (µm) pore-size Zefluor® polytetrafluoroethylene (PTFE) filter mounted in a closed-face cassette, at a nominal flow rate of 2.0 lpm. Analysis was performed according to NIOSH Manual of Analytical Methods (NMAL), Fourth Edition, Method 1401.[1] The limits of detection (LOD) and quantitation (LOQ) were determined using the standard deviation (sd) calculated from 10 field blanks. The LOD is 3 times the field blank sd, and the LOQ is 10 times the sd. For TP analyses, the LOD was 0.02 milligrams per sample (mg/sample), and the LOQ was 0.06 mg/sample. For benzene extractable analyses, the LOD and LOQ were 0.04 mg/sample, and 0.1 mg/sample respectively

Polycyclic Aromatic Compounds (PACs)

The sampling train consisted of 37-mm, 2µm pore size, Zefluor® filter to collect particulate PACs, connected in series with an ORBO-42 sorbent tube to collect volatile or semi-volatile PACs. Samples were collected at a nominal flow rate of 2.0 lpm, and were kept under refrigeration prior to analysis according to the NMAL, Fourth Edition, Method 5800.[1] During PAC sample analysis, each filter and tube set was combined and extracted with 4 ml of hexane. Each sample was fractionated using solid-phase and liquid-liquid extractions to concentrate the PACs into 4 ml of dimethyl sulfoxide (DMSO). Each aliquot was analyzed using a flow-injection technique, and was monitored using a spectrofluorometer. Since the excitation and emission wavelengths are not the same for all PACs, two sets of excitation and emission wavelengths were utilized. One set of wavelengths is more sensitive for the 2-ring and 3-ring compounds (254 nm excitation, 360 nm emission), and the other set of wavelengths is more sensitive for the 4-ring and higher compounds (254 nm excitation, 400 nm emission). Finally, calibration curves were established using a Supelco QTM mixture of 16 polynuclear aromatic compounds as surrogate standards. The LOD and LOQ for lower-molecular weight compounds were 0.8 µg/sample, and 2.6 µg/sample respectively. For higher-molecular weight compounds the LOD and LOQ were 0.1 µg/sample, and 0.45 µg/sample.

EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs),[2] (2) the American Conference of Governmental Industrial Hygienists' (ACGIH®) Threshold Limit Values (TLVs®),[3] and (3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[4] NIOSH encourages employers to follow the OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever is the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Aliphatic Amines

Aliphatic amines are a class of organic compounds derived from ammonia by replacing one or more hydrogen atoms with alkyl or alkanol radicals.[5,6] Amines are alkaline, with a characteristic odor which has been described as "fishlike," or ammoniacal.[5,6] Direct contact with amines can result in severe eye damage, and skin burns.[6] In sufficient concentrations, vapors from volatile amines can cause skin irritation and dermatitis, as well as irritation of nose, throat, and lung.[6] Visual disturbances, such as blurred or foggy vision, and appearance of rings around lights (halovision) have been noted as an adverse effect of exposure to certain organic amines, e.g., Dimethylethylamine (DMEA). Amine-induced visual disturbances are believed to be temporary and to have no permanent effects.

Studies of ethyleneamines, including diethylenetriamine (DETA) and triethylenetetramine (TETA), have demonstrated that these compounds can produce primary irritation and skin sensitization.[6] Asthmatic symptoms, observed among workers exposed to polyamines, suggest that polyamines can cause respiratory tract sensitization.[7] Investigators have found that exposure to DETA and TETA not only causes skin sensitization, but may also result in pulmonary sensitization.[6,7] TETA has been implicated as a cause of cross-sensitization to other amines.[7]

In alkanolamines, or amino alcohols, nitrogen is attached to the carbon of an alkyl alcohol.[5] These compounds are most commonly associated with eye and skin irritation.[6,7] Ethanolamine, a common alkanolamine, is a colorless liquid with a mild ammonia-like odor. Ethanolamine vapor is a skin, eye, and respiratory irritant and has some narcotic properties. In one study, liquid ethanolamine applied to the human skin for 1.5 hours caused marked redness.[8] No systemic effects from industrial exposure have been reported.[8] Despite the wide use of ethanolamine in industry, researchers reported that there are no accounts of worker injury.[6]

Diethanolamine (DEA) is another common amino alcohol. Although there is only limited information regarding DEA toxicity in humans, animal studies produced effects in bone marrow, kidney, testis, skin, and central nervous system.[9,7]

Exposure criteria for the amine compounds which were evaluated during this HHE are summarized in Table 1.

Asphalt Fume

Although the composition of asphalt fume cannot be easily characterized, one evaluation technique has been to sample total particulate. Total particulate is a measure of all airborne particulate which is collected on the sample filter. Current occupational exposure criteria from NIOSH and ACGIH for asphalt fume are expressed as total particulate. The NIOSH REL for asphalt fume is a 15-minute ceiling limit of 5 mg/m^3. ACGIH has established a TLV for asphalt fume of 5 mg/m^3 as an 8-hour TWA. There is no current OSHA PEL for asphalt fume.

The benzene-soluble particulate fraction (BSF) of the total particulate has been measured as a surrogate of exposure to polynuclear aromatic hydrocarbons (PAHs). Organic compounds are generally soluble in benzene, whereas inorganic compounds are not benzene soluble. Historically, the BSF concentrations were measured in asphalt studies in an attempt to differentiate between the asphalt fume and dirt or other dust present at asphalt construction operations. However, this method is nonspecific, and the BSF results may not be due solely to PAHs.

PAHs have received considerable attention since some have been shown to be carcinogenic in experimental animals. Analysis for unsubstituted PAHs has been applied to evaluate asphalt fume exposure. However, this approach provides limited information because asphalt fume contains numerous alkylated PACs that coelute, causing chromatographic interference, which prevents quantitation of specific compounds.

PACs refer to a set of cyclic organic compounds that includes PAHs, and also includes compounds that may have sulfur, nitrogen, or oxygen in the ring structure and alkyl substituted cyclics. Hundreds of PACs with varying degrees of alkyl substitutions are typically associated with asphalt materials. NIOSH investigators have hypothesized that PACs with 2 to 3 rings (referred to in this report as low-molecular-weight PACs) may be associated with more irritative effects, while the 4-to 7-ring PACs (termed high-molecular-weight PACs) may have more carcinogenic and/or mutagenic effects. It is not currently possible to definitively distinguish between these two PAC groups analytically; however, using two different spectrofluorometric detector wavelengths (360 nanometer [nm] and 400 nm) allows the detector to be more sensitive to PACs based on ring number. No exposure criteria have been established for PACs, PAHs, or BSF.

RESULTS

Nitrogen Compounds/ Amines

Bulk Samples

Physical and analytical differences were noted between the bulk sample of Wetfix 312 submitted by Pike Industries on October 5, 1998, and the bulk sample of Wetfix 312 that was obtained at the Pike HMA plant on October 21, 1998. The first bulk sample was semisolid, and contained numerous non-nitrogen compounds, such as alkanes and napthalenes. The second bulk sample was a viscous liquid which appeared to contain only nitrogen compounds (no hydrocarbons).

Although numerous nitrogen-containing compounds were detected in the polyamine mixtures, only a few were identified by GC-MS: ethanolamine, piperazine, (aminoethylamino)ethanol, diethanolamine, (aminoethyl)piperazine, (hydroxyethyl)piperazine, and triethylenetetramine. Most of the other nitrogen-containing compounds appeared to be aliphatic amines or amides.

Headspace samples collected over the asphalt bulks indicated that, as expected, the predominant compounds were C_9-C_{20} alkanes. A few nitrogen compounds were detected above the treated asphalt, however the presence of hydrocarbons resulted in significant interference.

Air Samples

Low concentrations of nitrogen compounds were detected in each of the air samples. The estimated concentrations of four identified amine compounds, and the total nitrogen mass in each sample are presented in Table 2. The compounds listed in the table do not necessarily represent the most prevalent nitrogen compounds that were present in the fume; rather they are identifiable compounds for which an estimate of concentration could be made.

The total nitrogen values represent only the mass of nitrogen contained in airborne compounds, and do not account for the mass of the other elements in these compounds. The nitrogen values indicate the presence of additional nitrogen-containing compounds (amines) that were not identified during this analysis. The unidentified compounds may include those which were identified in the bulk samples of Wetfix 312, i.e., ethanolamine, diethanolamine, piperazine, (aminoethyl)piperazine, (hydroxyethyl)piperazine, and triethylenetetramine. As noted above, the relative percent error in the data reported here is estimated at ±50%.

Total Particulate (TP)/ Benzene Soluble Fraction (BSF)

Because of an error during analysis, the analytical results cannot be matched with the samples; however, it was possible to calculate a range of concentrations for TP and BSF that encompasses the highest and lowest possible concentrations in PBZ and seat samples. Ranges were calculated using the largest and smallest sample results (mg/sample) in conjunction with the largest and smallest sample volumes. For these samples, the TP concentration of was determined to be 1.1 to 3.8 mg/m^3, and the BSF concentration was 0.28 to 3.6 mg/m^3. For area samples collected above the screed, the ranges were 2.0 to 7.2 mg/m^3, and 0.53 to 6.8 mg/m^3. Based on worksite observations, it appears that the actual personal exposures of monitored workers (including the seat sample) were likely to be considerably less than the 3.8 mg/m^3 maximum reported above. The true concentration of TP/BSF directly above the screed is likely to be closer to the upper-end of the reported ranges for samples collected above the screed.

Polycyclic Aromatic Compounds (PACs)

Table 3 summarizes the total PAC concentrations in area samples collected at the paver seat and the screed. The values reported in Table 3 are indicators of low- and high-molecular-weight compounds; however, these values are *not* additive. In every PAC sample, concentrations of low-molecular-weight PACs exceeded those of high molecular weight PACs, implying that the 2-3 ring PACs, felt to be more responsible for irritant effects, may be more abundant.

DISCUSSION

This HHE initially attempted to evaluate worker-exposure to aliphatic polyamines in the presence of asphalt fume; however, asphalt fume interfered with the detection, identification, and quantification of amine compounds. Another complicating factor was the lack of information on the composition of Wetfix 312. Thus, this evaluation attempted to assess low levels of a complex, poorly defined amine mixture, in the presence of relatively high concentrations of asphalt fume.

Only a few nitrogen-containing compounds were identified in bulk and air samples; however, the evaluation of total nitrogen, a marker for amines, indicated that additional unidentified nitrogen-containing compounds (presumably amines) were present. Since the total nitrogen values did not measure exposure to specific compounds, it is difficult to relate these results to possible health effects of exposure to specific aliphatic amines, or to a class of amines. Although these results indicate the presence of low levels of nitrogen-containing compounds, they provide no information as to the nature of the compounds. It should be noted, however, that exposure to certain amine compounds may cause not only irritative effects, but sensitization as well. One of these compounds, TETA, was detected in a bulk sample of Wetfix 312. However, TETA was not assessed in air samples, thus no information was provided on the potential for airborne exposure during paving.

Workers' TP exposures were less than the 5 mg/m^3 concentration established by ACGIH as an 8-hour TWA TLV. Since personal and seat samples were collected over periods ranging from 441 to 509 minutes, the results of these samples cannot be evaluated in terms of the 15-minute ceiling established by NIOSH as a REL. Although the exposure of the roller operators was not assessed, previous evaluations have found that the exposure of roller operators to asphalt fumes is typically much lower than that of paver operators, screed operators, and other workers closer to the point of application.[10,11,12,13,14,15,16]

The paver and the HMA transfer vehicle ("Shuttle Buggy") were equipped with local exhaust ventilation. Based on visual observations, it appeared that the ventilation system on the Shuttle Buggy captured much of the fume, and discharged it away from the operator and other workers. It appeared that HMA was well-enclosed soon after it was dumped into to the hopper. The system on the paver, however, was not effective in capturing fumes at the hopper (where HMA is deposited by the Shuttle Buggy) or at the screed. Depending on wind direction, emissions from the paver hopper and screed could result in exposure of the paver operator, screed operator(s), and any other nearby crew members.

During informal conversations, paving crew workers reported that they experienced no symptoms or health problems on the sampling date. Nevertheless, these individuals stated that they believed that the anti-strip additive was responsible for occasional headaches, upset stomach, fatigue, rashes, itchy eyes, and sore throats. In addition, there was an anecdotal report of an HMA plant worker who experienced a "reaction" to the additive. One person noted that he could smell the anti-strip additive in the fume, and he could detect the additive by this odor.

Additional occupational health issues noted during the site visit involved diesel exhaust and noise. Diesel exhaust from the Shuttle Buggy was discharged beneath the left side of the Shuttle Buggy near the individual described as the "truck dumper." It appeared that the exhaust pipe could be redirected to the right side of the Shuttle Buggy so that the exhaust stream would blow away from this person. In regard to noise, operators and workers on and near the paver and Shuttle Buggy were not wearing hearing protection. Although sound level measurements were not obtained on this date, data from previous HHEs during paving operations indicates a need for hearing protection near paving equipment. Hearing protection should be utilized in conjunction with a Hearing Conservation Program to help prevent a gradual loss of hearing from repeated exposure to excessive, continuous noise.

CONCLUSIONS

Workers were exposed to low levels of nitrogen-containing compounds while paving with HMA treated with a polyamine anti-strip additive. These compounds included several identified amines, as well as unidentified nitrogen compounds, which are presumed to have been amines. Without knowing the identities and concentrations of specific amines, the relationship between these compounds and potential health effects remains unclear. Thus, we are unable to address the question of a perceived increase of health effects associated with use of the anti-strip additive. Exposure to TP did not exceed the ACGIH TLV; however, it cannot be stated with absolute certainty that exposure to TP never exceeded the 15-minute NIOSH REL. (The uncertainty regarding the REL is due to the long sample periods employed during this HHE.)

RECOMMENDATIONS

The following recommendations are based on observations made during the survey and are intended to help ensure the safety and health of paving crew workers. These recommendations stem from our present understanding of the workers' occupational exposures and potential health effects associated with HMA paving operations.

1. Even though there is no conclusive evidence to associate the current anti-strip additive with reports of health problems, the company could investigate the substitution of a non-amine additive for the current additive. To avoid problems that could result from selecting an inappropriate substitute, the company should evaluate the ingredients of all possible substitutes to ensure that other, possibly significant health hazards are not introduced if a change is made.

2. To minimize asphalt fume generation, the hot mix should be applied at the lowest temperature possible that can maintain quality control specifications.

3. Use of hearing protection should be required where workers are engaged in work that exposes them to noise that equals or exceeds 85 decibels, A-weighted (85 dBA) as an 8-hour time-weighted average. Although sound level measurements were not obtained during this HHE, data from previous HHEs indicates a need for hearing protection near paving equipment. Noise monitoring data, which was reported to have been provided by Pike Industries' insurance carrier, should be reviewed to assess potential noise exposures. If there has been a change in equipment, or other factors which could affect noise levels, noise monitoring should be repeated to determine current noise exposure levels.

4. The exhaust pipe on the Shuttle Buggy should be directed away from the truck dumper to reduce this individual's exposure to diesel exhaust. NIOSH regards diesel exhaust as a potential occupational carcinogen which should be controlled by feasible engineering means.

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Table 1
Exposure Criteria: Amine compounds
Pike Industries
HETA 98-0034
October 21, 1998

Compound	Exposure Criteria		
	NIOSH REL	OSHA PEL	ACGIH TLV
Diethylamine	10 ppm, 8-hour TWA; 25 ppm, 15-minute STEL	25 ppm, 8-hour TWA	5 ppm, 8-hour TWA; 15 ppm, 15-minute STEL
Triethylamine	none established	25 ppm, 8-hour TWA†	1 ppm, 8-hour TWA; 3 ppm, 15-minute STEL
Ethanolamine	3 ppm, 8-hour TWA; 6 ppm, 15-minute STEL	3 ppm, 8-hour TWA	3 ppm, 8-hour TWA; 6 ppm, 15-minute STEL
Diethanolamine	3 ppm, 8-hour TWA	none established	0.47 ppm, 8-hour TWA ‡
Aminoethylaminoethanol	none established		
Piperazine			
Aminoethylpiperazine			
Hydroxyethylpiperazine			
Triethylenetetramine			

† This PEL was one of several PELs for which NIOSH provided comments to OSHA questioning the adequacy of the PELs with respect to protection of workers from recognized health hazards.
‡ To maintain consistency throughout this table, the units used by ACGIH for this TLV were converted from mg/m^3 to ppm..

Table 2
Amine Compounds and Total Nitrogen
Pike Industries
HETA 98-0034
October 21, 1998

Sample Number & Location	Sample Period (minutes)	Sample Volume (liters)	Estimated Concentration of Selected Compounds (ppb)				Total Nitrogen (ng/sample)
			DEA	TEA	2-(2-AEA)EtOH	1-(2-AE)PIP	
OVS-1 Screed Operator	440	430	<0.004	0.14	<0.003	<0.002	80
OVS-2 Paving Foreman	473	467	<0.004	0.13	<0.003	<0.002	500
OVS-3 Paver Seat	509	508	0.099	0.26	0.023	0.019	120
OVS-4 Screed 0833-1304	273	264	0.19	0.78	0.045	0.036	820
OVS-5 Screed 1308-1655	227	219	0.076	0.61	0.053	<0.005	696

ppb = parts per billion
ng/sample = nanograms of nitrogen per sample (1 ng = 1 billionth of 1 gram)
DEA = Diethylamine
TEA = Triethylamine
2-(2-AEA)EtOH = 2-(2-Aminoethylamino)ethanol
1-(2-AE)PIP = 1-(2-Aminoethyl)piperazine

< Value is less than the minimum detectable concentration (MDC). The MDC is determined by the analytical limit of detection, and the volume of the air sample. For Table 1, the MDC for samples OVS-1, 2, and 3 are based on an average sample volume of 468 liters; for samples OVS-4 and 5, the average sample volume is 241 liters.

Table 3
Polycyclic Aromatic Compounds
Pike Industries
HETA 98-0034
October 21, 1998

Location	Time (minutes)	Sample Volume (L)	Polycyclic Aromatic Compounds (μg/m^3)	
			Low MW	High MW
Paver Seat†	322 - 490	641 - 976	720 - 1100	46 - 70
screed (0833 - 1313)	280	570	1600	110
screed (1322 - 1455)	93	187	910	86

L = Liters
μg/m^3 = Micrograms of contaminant per cubic meter of air.
MW = Molecular weight. The values obtained for low and high molecular weight compounds are not additive. These values are used as indicators of low and high molecular weight compounds.

† The sampling pumps used to collect seat samples faulted during morning and afternoon sampling periods. The ranges reported in this table represent the combined results of the shortest and longest possible sampling periods.

For Information on Other
Occupational Safety and Health Concerns

Call NIOSH at:
1–800–35–NIOSH (356–4676)
or visit the NIOSH Homepage at:
http://www.cdc.gov/niosh/homepage.html

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